

Interview with Luna Leopold

*Note: This interview was done at Luna Leopold's home in Berkeley, CA. The video tape did not work, so this transcript is based on a backup audio tape we fortunately made.*

VR: Ok, so we'll, after our false start with the...

LL: Well, before you come back, there are three things I would recommend you look at that are not listed so far. Langbein and I wrote two papers to try to explain, in simply different words the whole concept, and I gave you those references to look at. And the third is I wrote a whole book about it, and I think you oughta read that. Well, now, the problem is basically this. Robin Vannote took my idea whole hawk and said "Geez that's a wonderful idea, it must apply to the biota." Swell. But if he'd called me, which he didn't, and I knew him very well, I'd have said "Look Robin, you're starting in a very difficult direction, because you've got a theory with no proof, and my suggestion is if you're going write such a paper, lay out, at least in principle, the kinds of investigations that you think oughta be made in order to start approaching the idea that this actually works in the biota." But the fact is that he published the idea without even suggesting how it might be verified. It took me fifteen years to develop that, and it was built step by step by making certain observations, recording them, and then seeing how they're going towards a whole. We didn't even see the end of it until 15 years had gone by. Therefore, the problem that Vannote got into is that he jumped the gun, in effect. Now, if you sat down and looked at the idea, that these interactions that occur all are stochastic around some kind of a mean, and that mean means most probable state. That being the case then, we should start out by saying, let us just take some examples in the biologic field. For example, the continuum idea which I started in 1954 which started with the downstream hydraulic geometry meant that things moved in the downstream direction, and there was a progression in the downstream direction. So, what might be the progression? For example, and I haven't thought these through in such detail that it's a workable system, the principle of biota in the stream, let's say of the insects on the stream rocks, ought to change progressively in keeping with some parameters that the river is dictating. Now what he mentions in the original paper, what the feeders on the organic material that's flowing downstream is feeding on the leakage. Is that the word he used?

VR: Mm-hmm...

LL: Well that's crazy, because it's not leakage at all. It's simply that there's more organic material available than is utilized by the organisms that are eating it. That's a very misconception, to label it that way. So, how would you measure this? Well, you would probably start out by saying "Let us take a certain variety of organisms, and we will start defining their distribution in number and size or in some other way, and see how that changed downstream." Or, some other way, or let's talk about the so-called leakage. Let's talk about how the excess organic material, which is food for the microorganisms, how does it change in variety and in mass downstream. Or, you might say "Let us talk about the total available mass downstream." None of those things were mentioned. And the thing is, that when he, as I understand it, but I never heard anything about it other than reading it, they went on this expedition up in Idaho, and the thing was

a complete bust, because they had no idea what the hell to do. And they therefore didn't do anything very constructive. And so after that, the whole thing dropped. It was a shame. So I would caution any scientist to be careful about starting with a hypothesis, and publishing the hypothesis without having the slightest idea how you're going to go about saying how it worked, and I think that's the problem that you ran into. Considering the fact that it took me a whole book to describe, one by one, all the features that went into this theory and how they all fit in together to make it a whole, and how the final breakthrough came about. And that's quite messy, you see, in the business of the stream biota. So, anyway, that's the gist of it the way I see it.

VR: How did you know Vannote? Was it through Ruth Patrick?

LL: Well I used to give a short course at the Stroud Laboratory for years, when he was director. I knew him very well. So I was really surprised when this came out in print, he never talked to me about it. I would have said "Wait a minute! Wait a minute, now. Take it easy. I agree with you, BUT..." Then of course, for reasons which I never did understand, Robin became very unstable after that. I don't know why, I don't know anything about the history, but I knew though, that there was a tendency, I felt, as indicated by this matter, for him to get ahead of himself. Which was too bad, because he was a very smart guy. So, what happened after that, I don't know, because he dropped out of science for quite a while, I'm told. I don't know. It was a good scientist gone awry, but I don't know why. There was something going on that we couldn't see, apparently.

VR: There was a large NSF grant on the River Continuum...

LL: Yes! There was indeed. And when I heard about this, I had submitted to NSF a very small grant, and when I heard about this, they turned my grant down. And I wrote to them and said "You took my idea, and gave a large amount of money." I said "Don't ever send me anything again, *in my life*." And they never did. I was very angry about it.

VR: You never saw a draft of the paper before?

LL: No.

VR: They didn't circulate that with you? Why do you think it's been so popular in terms of ... as a paper?

LL: Because it's a good idea! Of course it's a good idea! But how the hell do you get to a good idea? A good idea came from hard work! Read my book and see how many ways we went at it. Matter of fact, we didn't even put it all together until one instance in which I made an observation in the field that I had never expected, and no one had ever expected. And all of a sudden, I began to see what was happening. There was a *balance* between things. This was giving up something for that. And we had never seen this before, and that led to a whole lot of new things. So, try as we may, we simply chanced onto something because of an experiment I was running. It never occurred to me that this

was going to be a result. But then it took years after that to develop fully how this thing was gonna go. But my whole book is devoted to the whole question of how entropy operates in these systems, and why we're talking about probabilities, and the most logical state, the most reasonable state with the least variance. It was a long long process, and that's what Robin was simply avoiding, which I think was too bad. Good idea? Yes. Good idea.

VR: When you were doing this book, and you were thinking about this issue of entropy, were you thinking of it as having management implications, or more a theoretical explanation of how rivers worked?

LL: Both...yeah. Because...well that's a whole 'nother kettle of fish. It has management implications in this regard: that there aren't definite rules with definite outcomes. And any management has to realize that that's true. You're going to have deviations, which are natural. They're not deviations being wrong, they're simply deviations from the mean. Management doesn't usually look at it this way. They say "this must be so, and therefore that must be so," and it doesn't work that way, as we all know in biology, it just doesn't work that way. So, there are lots of other ways in which management is affected by this, but I'd have to think over one at a time the kind of things that might be affected. But management, yes. Yes indeed. What do you think?

VR: Well, I think it's certainly been talked about being used for management...

LL: But you see, they don't know how to use it because they haven't explored what this means in terms of the biota. It certainly is perfectly clear in terms of the physical system. Perfectly clear.

VR: Let me ask you. Can biologists and hydrologists interact together successfully? There's been a lot of talk about this happening. The AGU in the spring meeting will be meeting with biologists.

LL: Why don't you look at the last paper that McBain and Trush and I wrote. There's exactly the answer to your question. The most important thing that Trush and McBain did up there on the Trinity was to demonstrate in detail how the vegetation, the riparian corridor, interacted with the stream. And we put this together in a paper, that we published at the National Academy, which I think is the most important paper along this line in the whole business. And it's the first time that there has been a real integration of the hydrology part together with the biologic implications part, in one simple statement, because it involves these things. First, every part of the runoff cycle has got implications for the life biota. The high flow in the spring, the low flow in the summer, the medium flow at other times. The five year flood, the two year flood, the twenty-five year flood. Each one of those things has a specific relationship to what the biota need and operate on. There are many many examples of this. For example, that young man with the Italian name that I can't remember wrote a paper, a very good paper, a long paper, on the cottonwood grove that makes the beauty of Jackson Hole. He pointed out that because the floods had been cut off by the dam, these trees are going to decay, and there's gonna

be no reproduction, and Jackson Hole is going to be left without any trees. Why? Because the seeds of the cottonwood have to be lifted high enough up above the floodplain itself to be protected against the ordinary flood, which is what McBain and Trush and I have pointed out in that paper. If they are not so protected, you're not going to have any reproduction. Well, here's a very practical outcome of a perfect simple fact. You cut out that important detail of how the seeds get up where they can be protected, and you have no trees. That's a hell of a big thing, because where did Jackson Hole get its reputation? The beautiful corridor of cottonwoods down through Jackson Hole. That's an example of that. Then, we have in that paper...do you know that paper at all?

VR: Yes. I've just...

LL: Alright. Well, anyway, I drew a diagram in which we got all, divided into the various several parts, the effect on vegetation on the fish, on...in other words, separated, but show which part of the ?ramda? wavelength is devoted to each one of these items. This is a very clear explanation of how the environment for the fish is altered by various stages of flow. Anyhow, so there's, in my opinion, an example of just what you say – the collaboration between hydrology and the biologic sciences. I don't think there's a better example that I know of. So I say yes indeed, they can work together. There's lots of reasons why they won't, because of the engineering viewpoint of some of the agencies, but that's sooner or later we're gonna have to overcome.

VR: One of the things that I was looking for in this is the influences on the river continuum, and that's why we came to you first. What influenced your ideas about zonation? Were there any hydrologists working before you that had given you the idea?

LL: No.

VR: So this was all on your fifteen years of observation?

LL: That's right. It started out when I started to work on the reason for the width of the river being as we see it, and I began to see that the river width was connected with all these other things, and that it changed progressively downstream. Then we began to see, in that paper, between what I call the outer station and the downstream. That was the beginning of how the continuity from upstream to downstream is maintained in the physical sense. Everything went from there on.

VR: There was no indication that anyone in the literature had had this idea?

LL: No. No.

VR: I know that you did work in Africa and various areas throughout North America. Did you see much variation how hydrologists or biologists, how our streams are different.

LL: How what?

VR: There's a line that biologists always use when they hear something about a generalization: "But our streams are different." Did you see a lot of differences from geographic areas when you were doing this?

LL: No. The amazing thing is the more you look at streams on other continents, they fall into the same system that we see here in much more detail. I'm not sure if that's answering your question.

VR: Yeah.

LL: You look at the number of things we had to learn. First, meanders occur as hydrodynamic result without banks. They occur in ice, and they occur in the Gulf stream. That's a very important thing to note. Secondly, meanders occur without sediment. Very important things to know. These are different than any things we ever thought. These kinds of things. Have you read my book on this?

VR: Yes.

LL: Well, you get the idea, then.

VR: It's very interesting to note how so much of this was de novo, that it was original, because so often in science we see that people are building on ideas.

LL: Well, we all build on ideas, but this idea was basically my own. This particular idea.

VR: What about Ruth Patrick's role with Vannote and the continuum?

LL: Not at all.

VR: Not at all? So the connection between her and the academy was...

LL: No...no. She was extremely important in setting up the Strode Laboratory. She'd been tremendously important in getting money for the kind of research that interested her. And potent in the business of trying to give guidance to some of these companies like DuPont and also to the Savannah Flat down there. No, she was not interested. She would never concern herself with that. The way I got us into it was that I asked Ruth to give a course to us, which she did. So I brought all my scientists together from the geological survey, and I thought they might be interested, or should be interested, and we all took this course she gave. And so I started the whole business of "Let's get some biologic science going in the survey," and it did very well. It was never very large, and some of the people like Keith Slack actually retired long before the completed publication of all the things they had learned. But nevertheless, it was a very successful beginning.

VR: Did you ever use the phrase "the river as continuum?" Was that one you had used in talks, or putting the word continuum...

LL: (laughs) No, I used the word continuity, that's all. All the time. So, the continuum is just another way of saying it. They simply turned it into a noun instead of the... The word continuity implies not just... but anyhow, there's a slight difference.

VR: We hope that Vannote will come out here. Would you be interested in trying to get the two of you together?

LL: Not particularly. No.

PD: Picking up the paper for the first time, what did you think about it...the River Continuum Project that Vannote did.

LL: I think I told you exactly what I thought. A damn good idea. Except wait a minute now! You're gonna have a hard time presenting the idea without any indication of how you're gonna go about saying...how you're proving it.

PD: He didn't do his homework.

LL: No. I could immediately see that. It was quite clear that...Jumping the gun in science isn't going to do you much good. It doesn't work that way. Now, as a matter of fact, it becomes an albatross around your neck. If you have to...if you're in a position where now you have to prove yourself, but you're not ready to prove yourself, then this is trouble. And I would caution any scientist to be careful of that.

VR: The temptation, you know the big grant money that came their way was a...

LL: Sure! Of course! But you see, if I had been the National Science Foundation, and I looked at that, I would have said "Wait a minute now! That's a great idea, but now what are you gonna do from then on? What are you gonna do with this money?" And they didn't know what they were gonna do with their money. And what happened...nobody's ever been very forthcoming on what happened on that Idaho expedition. As far as I can make out from anything I've ever read or heard, it was a complete flop. They didn't learn anything from it that was useful. Sure, they made some observations, but it didn't tie in anything. Is that true?

VR: Pretty much. Did you ever deal with any of the other members?

LL: No. I've read their stuff, but I never met with them.

VR: Maybe we should turn this off now...

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